

# PATENT SPECIFICATION

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## DRAWINGS ATTACHED

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(72) Inventor BRIAN WILLIAM MANLEY



## (54) IMPROVEMENTS IN OR RELATING TO SCANNING AND IMAGING SYSTEMS

(71) We, MULLARD LIMITED, of Abacus House, 33 Gutter Lane, London, E.C.2., a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to scanning and imaging systems and more particularly to airborne scanning and image transmission systems.

It is known to mount a television camera system with associated radio transmitter on a projectile or missile for the purpose of transmitting to a remote receiver a video signal representing an image viewed from the projectile or missile. Furthermore, it is known to simplify the scanning of the camera by utilising a rotary motion of the missile itself as one of the two scanning movements normally used to obtain a television raster. In one such proposal, an electronic camera tube is used to provide only the line scan and such scan is substantially parallel to the axis of rotation of the missile, the frame scan being obtained by the rotation of the camera with the missile.

In spite of simplifications of this kind, the use of an electronic camera tube with associated scanning equipment in both expensive (in view of the expendable nature of the missile) and very difficult to construct with the degree of ruggedness required for use in a missile.

These difficulties are even greater when the missile is not a rocket which suffers only limited acceleration during the launching but a projectile which is actually fired from say, a mortar.

It is an object of the present invention to provide simplified scanning means which are cheap and intrinsically robust, and which are thus better suited for mounting in a non-spinning missile such as, for example, a mortar bomb.

It is a further object of the invention to provide an improved ground survey or

ground imaging system based on the use of such scanning means.

According to a first aspect, the invention provides a ground survey or ground imaging system comprising a missile for transmitting video signals corresponding to an image of the terrain during flight, a missile launcher and a receiver for video signals transmitted by the missile, said missile being of the non-spinning type but having a rotary part adapted to spin in flight on a longitudinal axis parallel to the direction of flight, a photosensitive device on said part adapted to receive radiation from a single direction or line of sight at an acute forward angle to said axis, means for deriving a video signal from said photosensitive device, and a transmitter for transmitting said video signal, and the receiver being adapted to store said signals and display them by means of a spiral scan display system so adjusted that the end of the scan (corresponding to the point of impact of the missile) is located substantially at the centre of the display.

According to a second aspect, the invention provides a missile of the non-spinning type having a rotary part adapted to spin in flight on a longitudinal axis parallel to the direction of flight, a photosensitive device on said part adapted to receive radiation from a single direction or line of sight at an acute forward angle to said axis, means for deriving a video signal from said photosensitive device, and a transmitter for transmitting said video signal to a receiver remote from the missile.

With such a system it is possible to obtain a single spiral scan of a ground area which is approached by the missile since the line of sight of the photo-sensitive means describes a cone of fixed angle. As the cone approaches the ground the diameter of the said cone at the target is, of course, gradually reducing and this reduction in radius provides the radial component of the spiral scan. This simple scanning mode is possible because the missile, being of the mortar type, is designed so that it can be fired on a

steep upward trajectory followed by a correspondingly steep descent onto a ground target. The photo-sensitive device and transmitter can be switched on during the downward flight and the bomb will then transmit a spirally scanned view of the terrain beneath, and the picture will be complete as the bomb approaches impact on the ground. Such a system provides a very economical method of surveying a target area on the ground and the bomb may be used entirely for this purpose and not as a weapon.

For the purpose of synchronising the receiver display with the missile scan, it is possible to obtain a synchronisation pulse at every rotation of the rotary part of the missile, such pulse being obtained by relating the spin of said rotary part to a stable reference which may either be a gyro-stabilised element in the missile or an external ground reference. However, if the system is applied to a mortar bomb which is sufficiently stable in flight, a synchronisation pulse can be obtained in a preferred manner by reference to a marker on the non-rotating body of the missile.

The invention will now be described in greater detail as applied to the latter preferred case in which the missile is stable and an embodiment thereof will be described with reference to the diagrammatic drawings accompanying the Provisional Specification.

Referring to Figure 1 of the drawings, a general view of the missile shows it having a main body B with tail fins F and a spinning nose unit N which is rotated in flight by the slip-stream acting on a plurality of curved inclined vanes V. Visible schematically on the nose unit N is an aperture L through which external radiation can enter to provide the video information.

Figure 2 shows an enlargement of the nose cone unit in which the propelling vanes V are omitted for simplicity and a nose aerial A is shown in a fragmentary manner, such aerial being aligned on the axis of rotation X-X.

The photo-sensitive device is shown at P and external radiation is focussed thereon through a port and lens system L aligned with a line of sight S which is at an angle  $\alpha$  to the axis of rotation, such angle being for example about  $40^\circ$ .

The video signal provided by the photo-sensitive device P is supplied to a radio transmitter Tx which transmits the composite video signal via the aerial A. Such signal includes synchronisation pulses which may be provided at every revolution by reference to a timing marker M provided on the non-rotating body B of the missile.

The system of Figure 1 and 2 can be used in daylight although it may be more useful or suitable for use in infra-red imaging of terrain at night or, possible, through cloud

or fog. Such an application is passive in the accepted sense that it requires no generation of imaging radiation and relies on existing radiation from the target. However, it is possible to use the device as an active device analogous to a flying spot scanner. For this purpose the device would include an additional element in the form of a light source such as a laser which would provide illumination along the line of sight S so that the photosensitive device P would receive reflected radiation from the ground.

The video signals transmitted by the missile can be stored (e.g. on a video tape) and displayed subsequently by a spiral scan display system so adjusted that the end of the scan (corresponding to the point of impact of the missile) is located at the centre of the display. Such adjustment (which may be referred to as "centring") can be achieved by playing a video tape backwards (i.e. in reverse) starting the scan at the centre of the display with the last video signals received.

If instead, or in addition, it is desired to view the ground image while it is being formed during the flight of the missile, approximate centring can be achieved by estimating the useful flight time of the missile and choosing a corresponding radial speed for the spiral scan (the useful flight time will, of course, depend *inter alia* on the relative launching and landing altitudes and the firing angle).

As a variant of the above methods, video storage can be effected simultaneously with an initial display based on estimated centring, the display being then repeated with the aid of the stored video signals and manual centring adjustment.

In night-viewing and infra-red imaging applications involving weak signals it is usually preferred to have a video signal which has been chopped so as to provide the equivalent of a modulated carrier which can more easily be amplified. This can be done conveniently in the present case by mechanical means. As one example, the rotating part or nose cone N, with its vanes V, can be enclosed in a stationary cage C of longitudinal bars (Figure 3) which intermittently block the entry of radiation to the photo-sensitive system L-P while still allowing the slip-stream to act on the vanes V.

The scanning method will be understood more clearly from Figure 4 in which the missile is shown in two consecutive positions B1-B2 as it approaches the ground. The scanning line or line of sight is at an angle  $\alpha$  to the line of flight (shown vertical) and is shown at S1 and S2. At B1 the radius of the ground scan is R1 and this corresponds to a radius r1 on the spiral display scan. At the lower position B2 the ground radius is reduced to R2 and the display radius is correspondingly reduced to r2. Finally, the dis-

play scan should reach the centre O when the missile lands.

Although the required steep descent can be obtained, as mentioned above, by firing the missile on a steep upward trajectory, it is also possible to fire it on a lower trajectory (e.g. an elevation 30°-45°) and rely on the missile having an air brake system which can be brought into action when the missile is in flight at a controlled distance from the launching site. This can be done either by remote control or by a simple timing mechanism carried by the missile and set before launching. By such means the missile can be made to fall vertically or substantially vertically during the final scanning phase of its flight.

#### WHAT WE CLAIM IS:—

1. A ground survey or ground imaging system comprising a missile for transmitting video signals corresponding to an image of the terrain during flight, a missile launcher and a receiver for video signals transmitted by the missile, said missile being of the non-spinning type but having a rotary part adapted to spin in flight on a longitudinal axis parallel to the direction of flight, a photo-sensitive device on said part adapted to receive radiation from a single direction or line of sight at an acute forward angle to said axis, means for deriving a video signal from said photo-sensitive device, and a transmitter for transmitting said video signal, and the receiver being adapted to store said signals and display them by means of a spiral scan display system so adjusted that the end of the scan (corresponding to the point of impact of the missile) is located substantially at the centre of the display.

2. A missile of the non-spinning type having a rotary part adapted to spin in flight on a longitudinal axis parallel to the direction of flight, a photo-sensitive device on said part adapted to receive radiation from a single direction or line of sight at an acute forward angle to said axis, means for deriving a video signal from said photo-sensitive device, and a transmitter for transmitting said video signal to a receiver remote from the missile.

3. A missile as claimed in Claim 2 where-

in, for the purpose of synchronising the receiver display with the missile scan, means are provided to obtain a synchronisation pulse at every rotation of the rotary part of the missile, such pulse being obtained by relating the spin of said rotary part to a stable reference.

4. A missile as claimed in Claim 3 wherein said reference is a marker on the non-spinning body of the missile.

5. A missile as claimed in any of Claims 2 to 4 having a main body with tail fins and a spinning nose unit which is rotated in flight by a plurality of inclined vanes.

6. A missile as claimed in any of Claims 2 to 5 employing a radio transmitter to transmit a composite video signal via an aerial, such signal including synchronisation pulses provided at every revolution by reference to a timing marker provided on the non-rotating body of the missile.

7. A missile as claimed in any of Claims 2 to 6 adapted to operate as a passive imaging device in the sense that it requires no generation of imaging radiation and relies on existing radiation from the target.

8. A missile as claimed in any of Claims 2 to 7 including an air brake system which can be brought into action when the missile is in flight at a controlled distance from the launching site.

9. A receiver for a system as claimed in Claim 1, wherein the display is centred by storing the video signals on a video tape or equivalent and playing the video tape backwards while starting the scan at the centre of the display with the last video signals received.

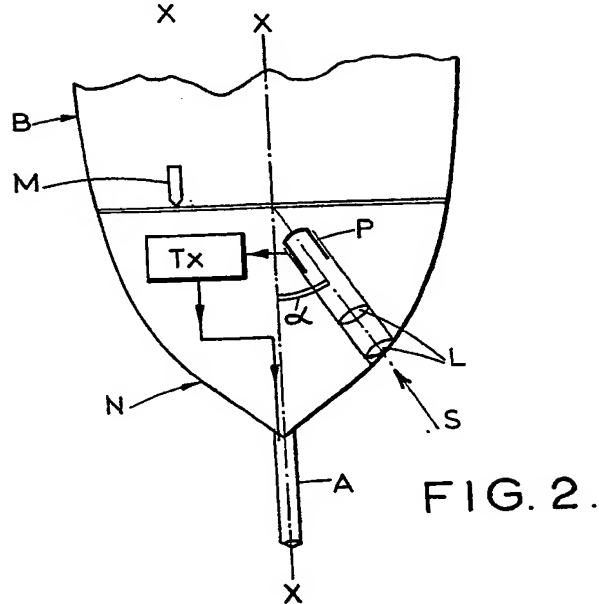
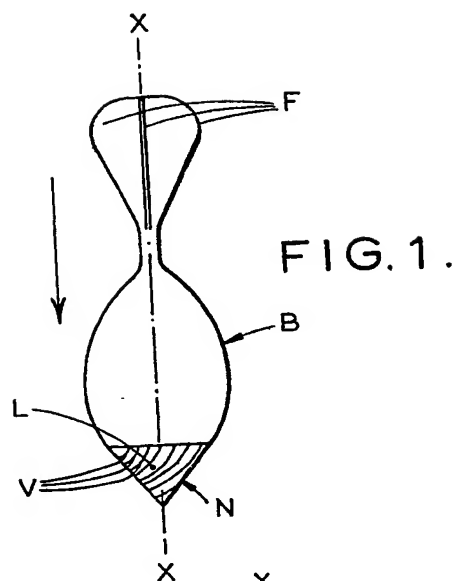
10. A missile substantially as described with reference to the drawings accompanying the Provisional Specification.

11. A ground survey or ground imaging system as claimed in Claim 1 employing a missile as claimed in any of Claims 2 to 8 or Claim 10.

G. V. CARCASSON,  
Chartered Patent Agent,  
Mullard House,  
Torrington Place,  
London, W.C.1,  
Agent for the Applicants.

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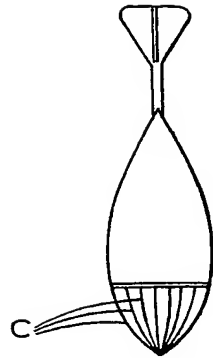


FIG. 3 .

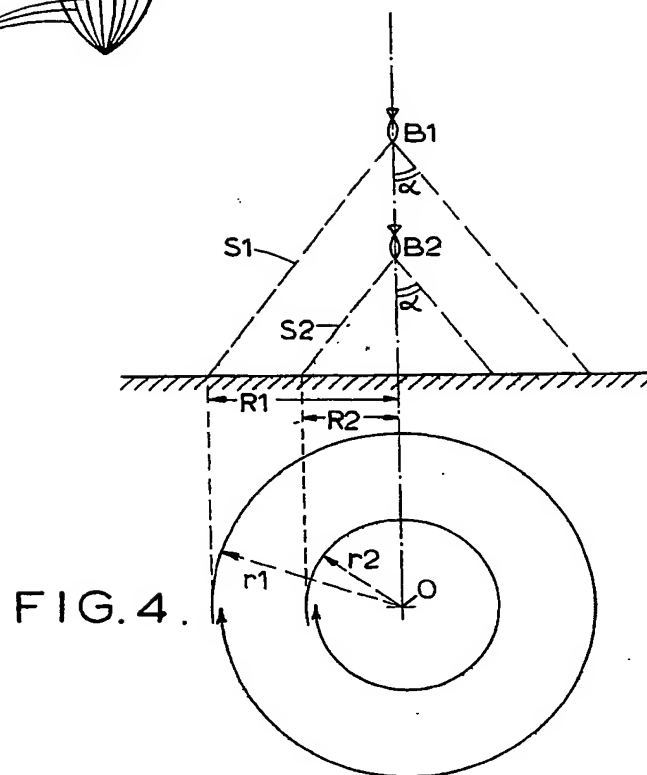


FIG. 4 .

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